PATENT ABSTRACTS OF JAPAN

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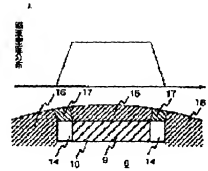
(54) PERMANENT MAGNET DYNAMO-ELECTRIC MACHINE AND MOTOR-DRIVEN VEHICLE USING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To suppress a torque ripple while a reluctance torque by an auxiliary pole is obtained, by a method wherein magnetic gaps are formed between a permanent magnet and auxiliary pole parts adjacent to the permanent magnet in a circumferential direction.
SOLUTION: Magnetic gaps 14 are formed between a permanent magnet 9 and auxiliary pole parts adjacent to the permanent magnet 9 in a circumferential direction to relieve the change of a magnetic flux distribution. Bridge parts 17 are formed between a pole piece part 15 and auxiliary poles 16 on the surface of a rotor by the gaps 14, and certain distances are provided between the pole piece part 15 and the auxiliary poles 16. Therefore, the change of a magnetic flux distribution which is more gentle than that of a conventional constitution is obtained, so that a cogging torque and a torque ripple can be suppressed. Further, if a dynamo-electric machine rotates in one direction only, the magnetic gap 14 may be formed on the one end in the circumferential direction of a permanent magnet 9. Moreover, if the similar gaps 14 are formed between the auxiliary pole parts and the arc-shaped or trapezoidal permanent magnets 9, the similar effect can be obtained.



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CLAIMS

[Claim(s)]
[Claim 1] the stator which is characterized by providing the following and which gave the coil to the stator core, and two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- a hole -- annular -- forming -- and this permanent magnet insertion -- the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further The aforementioned permanent magnet. An opening magnetic between the aforementioned auxiliary magnetic pole sections which adjoined the aforementioned permanent magnet at the hoop direction.
[Claim 2] permanent magnet rotation electrical machinery according to claim 1 -- setting -- the aforementioned permanent magnet insertion -- the permanent magnet rotation electrical machinery characterized by having established the crevice in the bottom of a hole and having arranged the aforementioned permanent magnet to this crevice
[Claim 3] Permanent magnet rotation electrical machinery characterized by having arranged the non-magnetic material to the aforementioned opening in permanent magnet rotation electrical machinery according to claim 1 or 2.
[Claim 4] Permanent magnet rotation electrical machinery characterized by making hoop-direction width of face of the field by the side of the stator of the aforementioned opening larger than the hoop-direction width of face of the field by the side of the wastepaper constant child of this opening in permanent magnet rotation electrical machinery according to claim 1 to 3.
[Claim 5] It is the permanent magnet rotation electrical machinery characterized by the hoop-direction cross section of the aforementioned opening being a triangle-like in permanent magnet rotation electrical machinery according to claim 4.
[Claim 6] It is the permanent magnet rotation electrical machinery which the aforementioned pole piece section is connected to the aforementioned auxiliary magnetic pole through the bridge section in permanent magnet rotation electrical machinery according to claim 1 to 5, and is characterized by the stator side front face of the aforementioned bridge section and an opening side front face being abbreviation parallel.
[Claim 7] It is the permanent magnet rotation electrical machinery characterized by forming so that the aforementioned bridge section may be extended at right angles to the inclined plane of the aforementioned opening in permanent magnet rotation electrical machinery according to claim 6.
[Claim 8] Permanent magnet rotation electrical machinery characterized by providing the following. The stator which gave the coil to the stator core, two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- a hole -- annular -- forming -- and this permanent magnet insertion -- the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further -- setting -- an opening magnetic between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section
[Claim 9] It is the permanent magnet rotation electrical machinery characterized by the aforementioned opening touching the hoop-direction edge of the field by the side of the stator of the aforementioned permanent magnet in permanent magnet rotation electrical machinery according to claim 8.
[Claim 10] It is the permanent magnet rotation electrical machinery characterized by having extended the aforementioned opening inside the aforementioned permanent magnet in permanent magnet rotation electrical machinery according to claim 9.
[Claim 11] It is the permanent magnet rotation electrical machinery characterized by having extended the aforementioned opening in the shape of a rectangle inside the aforementioned permanent magnet in permanent magnet rotation electrical machinery according to claim 9.
[Claim 12] A hole is formed annularly, the stator which gave the coil to the stator core, and two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- In the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further and this permanent magnet insertion -- Permanent magnet rotation electrical machinery characterized by having prepared the magnetic opening between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section, and making the aforementioned pole piece section fix to the aforementioned auxiliary magnetic pole section by nonmagnetic pole piece supporter material.
[Claim 13] It is the permanent magnet rotation electrical machinery characterized by inserting the aforementioned pole piece supporter material from the shape of a typeface of KO, and both the shafts of the aforementioned rotor core in permanent magnet rotation electrical machinery according to claim 12.
[Claim 14] A hole is formed annularly, the stator which gave the coil to the stator core, and two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- In the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further and this permanent magnet insertion -- Prepare a magnetic opening between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section, and the permanent magnet supporter material which combined the magnetic material and the non-magnetic material between the aforementioned pole piece section and the aforementioned permanent magnet is arranged. And permanent magnet rotation electrical machinery characterized by having arranged the aforementioned magnetic material of the aforementioned permanent magnet supporter material between the aforementioned pole piece section and the aforementioned

permanent magnet, and making the aforementioned non-magnetic material engage with the aforementioned auxiliary magnetic pole section.

[Claim 15] Permanent magnet rotation electrical machinery characterized by having arranged the non-magnetic material to the aforementioned opening in permanent magnet rotation electrical machinery according to claim 8 to 14.

[Claim 16] It is the permanent magnet rotation electrical machinery characterized by the hoop-direction width of face of the aforementioned permanent magnet being smaller than the hoop-direction width of face of the aforementioned auxiliary magnetic pole section in permanent magnet rotation electrical machinery according to claim 1 to 15.

[Claim 17] The electric vehicles driven with permanent magnet rotation electrical machinery according to claim 1 to 16.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the electric vehicles which used rotation electrical machinery and rotation electrical machinery, especially relates to the electric vehicles using the permanent magnet rotation electrical machinery using the permanent magnet as a magnetic-flux generating means, and permanent magnet rotation electrical machinery.
[0002]
[Description of the Prior Art] The permanent magnet rotation electrical machinery which used the permanent magnet for the magnetic field generating means of a rotator is conventionally used as a kind of rotation electrical machinery.
[0003] As conventional permanent magnet rotation electrical machinery, there are some which juxtaposed two or more permanent magnets and were fixed to the front face of a rotator so that surface magnet structure, i.e., an adjoining permanent magnet, may serve as reversed polarity at a hoop direction.
[0004] However, the permanent magnet rotator of the permanent magnet embedded structure which the thing of surface magnet structure inserted the permanent magnet in the hole extended to the shaft orientations in a rotator since possibility that a permanent magnet will exfoliate with a centrifugal force at the time of high-speed rotation is high, and was fixed is indicated by JP,5-76146,A.
[0005] Moreover, what formed the opening in the periphery of a rotator from the end face of each permanent magnet which installed the composition in the case of giving a skew to the rotator of a permanent magnet embedded structure in the interior of a rotator for the purpose of making it simple is indicated by JP,5-236687,A.
[0006]
[Problem(s) to be Solved by the Invention] However, with the above-mentioned conventional technology, there is a problem that it is incompatible with acquiring the reluctance torque by the auxiliary magnetic pole in reduction of cogging torque or torque throb (both are hereafter called "torque throb" collectively).
[0007] Reluctance torque can be acquired by using the rotator member between the adjoining permanent magnets as an auxiliary magnetic pole, and controlling the synthetic vector of the armature magnetomotive force of a stator by the rotator of a permanent magnet embedded structure to turn to a hand-of-cut side from the center position of this auxiliary magnetic pole. This reluctance torque is added to the main torque by the permanent magnet, increases the total torque of rotation electrical machinery, and raises efficiency.
[0008] On the other hand, in order to use the permanent magnet which has always generated magnetic flux irrespective of the existence of energization in permanent magnet rotation electrical machinery, a rotator always receives the force according to the physical relationship of a permanent magnet and the stator salient pole section, and the force changes in throb at the time of rotation. It serves as torque throb and appears. This bars smooth rotation of a rotator and produces the problem that operation stabilized as rotation electrical machinery cannot be obtained.
[0009] Since it has the auxiliary magnetic pole, although it is possible to acquire reluctance torque, since the distance of a permanent magnet and an auxiliary magnetic pole is minute to a hoop direction, the abrupt change of a flux density distribution there appears, and torque throb produces the permanent magnet rotator indicated by JP,5-76146,A.
[0010] Although it becomes loose [the permanent magnet rotation electrical machinery currently indicated by JP,5-236687,A] flux density distribution changing between the permanent magnets which adjoined each other that the opening is prepared between permanent magnets or by filling up with the adhesive filler which becomes an opening from non-magnetic material and it is hard to generate cogging torque or torque throb, since this opening or filler does not achieve the duty of an auxiliary magnetic pole, reluctance torque cannot be acquired.
[0011] this invention aims at offering the permanent magnet rotation electrical machinery which can suppress torque throb, and the electric vehicles using it, acquiring the reluctance torque by the auxiliary magnetic pole in view of the above-mentioned situation.
[0012]
[Means for Solving the Problem] A hole is formed annularly. the stator by which invention according to claim 1 gave the coil to the stator core, and two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- In the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further and this permanent magnet insertion -- It is characterized by preparing a magnetic opening between the aforementioned permanent magnet and the aforementioned auxiliary magnetic pole section which adjoined the aforementioned permanent magnet at the hoop direction.
[0013] This magnetic opening makes loose flux density distribution change between the permanent magnet in the hoop direction of a rotator, and an auxiliary magnetic pole, and decreases torque throb. Therefore, this opening may be mere space, and may be arranged or filled up with a non-magnetic material.
[0014] moreover, this opening -- the ends of a permanent magnet -- you may be -- moreover, the hand of cut of rotation electrical machinery and its use -- the hoop direction of a permanent magnet -- either -- you may be only in an end
[0015] However, by preparing the above-mentioned opening in the hoop-direction edge of a permanent magnet, positioning of a magnet may become unstable at the time of high-speed rotation etc. then -- being according to claim 2 -- like -- the

aforementioned permanent magnet insertion -- it is possible to establish a crevice in the bottom of a hole, and to arrange the aforementioned permanent magnet to this crevice, or to position a permanent magnet by the thing [arranging a non-magnetic material] according to claim 3 to the aforementioned opening like

[0016] Moreover, if flux density distribution change to a stator is made loose, since it is sufficient for the aforementioned opening, it can also assist an operation of an auxiliary magnetic pole by changing the configuration. That is, a thing [constituting so that hoop-direction width of face of the field by the side of the stator of the aforementioned opening may be made larger than the hoop-direction width of face of the field by the side of the wastepaper constant child of this opening or the magnetic flux of an auxiliary magnetic pole may tend to go a permanent magnet around like by / according to claim 5 / constituting the hoop-direction cross section of the aforementioned opening like so that it may become triangle-like] according to claim 4 is also possible, and more reluctance torque can be acquired.

[0017] Furthermore, it is possible to suppress the magnetic flux according to claim 6 which the aforementioned pole piece is connected to the aforementioned auxiliary magnetic pole through [like] the bridge section, and forms a stator side front-face side [of the aforementioned bridge section] and opening side front face in abbreviation parallel, or is revealed to the auxiliary magnetic pole from the member by the side of the stator of a permanent magnet to an opening by [according to claim 7] forming so that it may be extended by the aforementioned bridge section at right angles to the inclined plane of the aforementioned opening like.

[0018] Especially according to invention according to claim 7, the centrifugal force concerning a permanent magnet can be supported according to the hauling force of the bridge section, and the permanent magnet rotation electrical machinery more which can be rotated high-speed can be offered.

[0019] A hole is formed annularly, the stator by which invention according to claim 8 gave the coil to the stator core, and two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- and this permanent magnet insertion -- it consists of rotators which embedded the permanent magnet at the hole, and is characterized by preparing a magnetic opening between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section in the permanent magnet rotation electrical machinery which has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further

[0020] Like [this magnetic opening] invention according to claim 1, flux density distribution change between the permanent magnet in the hoop direction of a rotator and an auxiliary magnetic pole is made loose, and torque throb is decreased.

[0021] Moreover, a thing [suppressing the magnetic flux according to claim 10 which reveals the aforementioned opening to the auxiliary magnetic pole section from the field by the side of the stator of a permanent magnet by / according to claim 11 / forming the aforementioned opening like so that it may be extended in the shape of a rectangle inside the aforementioned permanent magnet so that it may be extended inside the aforementioned permanent magnet like] according to claim 9 is possible so that the hoop-direction edge of the field by the side of the stator of the aforementioned permanent magnet may be touched in the aforementioned opening like.

[0022] However, in inner rotor type rotation electrical machinery, preparing an opening in the pole piece section in the stator side of a permanent magnet may hurt the bearing power to the centrifugal force to a permanent magnet at the time of high-speed rotation.

[0023] Then, the stator according to claim 12 which gave the coil to the stator core like, A hole is formed annularly, two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- In the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further and this permanent magnet insertion -- Like a publication to preparing a magnetic opening between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section, and making the aforementioned pole piece section fix to the aforementioned auxiliary magnetic pole section by nonmagnetic pole piece supporter material, or a claim 13 By being inserted from the shape of a typeface of KO, and both the shafts of the aforementioned rotor core, the aforementioned pole piece supporter material can support the centrifugal force of the permanent magnet concerning the pole piece section in the auxiliary magnetic pole section.

[0024] Moreover, the stator according to claim 14 which gave the coil to the stator core like, A hole is formed annularly, two or more permanent magnet insertion which forms the pole piece section in a stator side through the auxiliary magnetic pole section in between -- In the permanent magnet rotation electrical machinery which consisted of rotators which embedded the permanent magnet at the hole, and has arranged the aforementioned rotator with a rotation opening to the aforementioned stator further and this permanent magnet insertion -- Prepare a magnetic opening between the aforementioned pole piece section and the aforementioned auxiliary magnetic pole section, and the permanent magnet supporter material which combined the magnetic material and the non-magnetic material between the aforementioned pole piece section and the aforementioned permanent magnet is arranged. And the bearing power to the centrifugal force which a permanent magnet receives similarly can be made to increase also by arranging the aforementioned magnetic material of the aforementioned permanent magnet supporter material between the aforementioned pole piece section and the aforementioned permanent magnet, and making the aforementioned non-magnetic material engage with the aforementioned auxiliary magnetic pole section.

[0025] Furthermore, the bearing power to the centrifugal force which a permanent magnet receives can be made to increase like also by [according to claim 15] arranging a non-magnetic material to the aforementioned opening.

[0026] Moreover, the centrifugal force concerning a permanent magnet is [like] effectively mitigable also by [according to claim 16] making hoop-direction width of face of the aforementioned permanent magnet smaller than the hoop-direction width of face of the aforementioned auxiliary magnetic pole section.

[0027] Invention according to claim 17 is electric vehicles driven with a claim 1 or permanent magnet rotation electrical machinery according to claim 16, and can offer electric vehicles with the stable driving gear with little cogging torque.

[0028] In addition, even if the above-mentioned rotation electrical machinery is which thing of a generator and a motor, an inner rotor and an outer rotor, a rotated type and a linear type, a concentrated winding, and distribution volume stator structure, it can apply this invention.

[0029] Moreover, invention of all above is not dependent on the configuration of a permanent magnet, and anythings can apply a rectangular parallelepiped, an arc form, a trapezoid, etc., and it does the same effect so.

[0030]

[Embodiments of the Invention] Hereafter, the operation gestalt of this invention is explained in detail using drawing.

[0031] Drawing 1 shows the hoop-direction cross section of the permanent magnet rotation electrical machinery of the inner

rotor type concentrated-winding stator structure which is 1 operation gestalt of this invention.
[0032] Rotation electrical machinery consists of a stator 1 and a rotator 2, and these are mutually arranged with a rotation opening, as shown in drawing.
[0033] A stator 1 consists of a stator core 3 and a stator winding 4, and a stator core 3 consists of the core section 5 and the stator salient pole section 6 further. The magnetic circuit for letting magnetic flux pass in the stator salient pole section 6 is formed in the core section 5, and a stator winding 4 is intensively wound around the stator salient pole section 6.
[0034] A rotator 2 consists of a shaft 7, a rotor core 8, and a permanent magnet 9. the permanent magnet insertion which inserts a permanent magnet 9 in a rotor core 8 -- the hole which lets a hole 10 and a shaft 7 pass is pierced by shaft orientations, and a permanent magnet 9 and a shaft 7 are inserted and fixed, respectively
[0035] thus, the permanent magnet insertion which this operation gestalt is the so-called thing of a permanent magnet embedded structure, and adjoins mutually by arranging a permanent magnet 9 annularly to a rotator 2 -- the member between holes 10 can be operated as the auxiliary magnetic pole section 16
[0036] That is, if the synthetic vector of the armature magnetomotive force by the stator winding 4 is controlled by the control unit which is not illustrated to turn to a hand-of-cut side from the center position of an auxiliary magnetic pole, the magnetic flux generated from the stator winding 4 will go a permanent magnet 9 around through the auxiliary magnetic pole section 16, and reluctance torque will occur with it. This is effective in especially low-speed operational status, and the above-mentioned reluctance torque can acquire torque high as a motor by joining the usual torque by the permanent magnet 9.
[0037] Drawing 3 shows the cross-section structure of the shaft orientations of the permanent magnet rotation electrical machinery concerning this operation form.
[0038] The shaft 7 which the stator 1 was fixed to the inner skin of housing 11 as shown in drawing, and was inserted and fixed to the rotator 2 is held with bearing 13 and the end bracket 12 at a stator 1 so that a rotator 2 may have a rotation opening in a stator 1 and may touch it free [rotation].
[0039] With this operation form, what has the permeability higher than a permanent magnet 9 as a material of a rotor core 8, for example, a high permeability magnetic material like a silicon steel, is used. The eddy current loss generated inside a magnet can be decreased by this, and the above-mentioned auxiliary magnetic pole section 16 can be operated more effectively.
[0040] In addition, this invention can be applied also in any of a generator and motor, inner rotor and outer-rotor, rotated type and linear type, and concentration volume and distribution volume stator structure, and the same effect is acquired.
[0041] This operation form forms the magnetic opening 14 between a permanent magnet 9 and the auxiliary magnetic pole section 16 which adjoined this permanent magnet 9 at the hoop direction.
[0042] Drawing which expanded the circumference of the arbitrary permanent magnets 9 in drawing 1 to drawing 2 is shown. as shown in drawing, an opening 14 is formed in the hoop-direction edge of a permanent magnet 9 -- as -- permanent magnet insertion -- a hole 10 is formed, and a permanent magnet 9 is inserted there and it fixes to it This opening was extended to shaft orientations and is in contact with a permanent magnet 9 and the auxiliary magnetic pole section 16.
[0043] An operation of this opening 14 is explained using drawing 4 and drawing 5 .
[0044] Drawing 4 and drawing 5 are the hoop-direction cross section of the permanent magnet 9 circumference, and drawing showing the relation of the flux density distribution generated by the permanent magnet 9 from the circumferential front face of a rotator 2. As for drawing 4 , drawing 5 shows the conventional rotator for the rotator using the above-mentioned operation form.
[0045] It functions as a member which transmits the magnetic flux in which, as for the pole piece section 15 of a rotor core 8, the permanent magnet 9 generated both sides to a stator 1, moreover, the adjacent permanent magnet insertion -- the auxiliary magnetic pole section 16 in the member between holes 10, i.e., drawing, functions as an auxiliary magnetic pole which generates reluctance torque
[0046] The graph in the upper part of drawing 4 and drawing 5 expresses the flux density distribution generated by the permanent magnet 9 from the stator side front face of a rotator 2. As for the magnetic flux which a permanent magnet 9 generates, both drawings show the flux density distribution of simultaneously regularity in the pole piece section 15. On the other hand, in the auxiliary magnetic pole section 16, the magnetic flux by the permanent magnet 9 is hard to be transmitted, and the magnetic flux generated from the stator side front face of a rotator 2 is set to about 0.
[0047] however, the permanent magnet insertion prepared in the rotor core 8 like drawing 5 in the conventional rotator -- a hole -- since the permanent magnet 9 is arranged so that the 10 whole may be buried, in near the boundary of the pole piece section 15 and the auxiliary magnetic pole section 16, a rapid change of a flux density distribution as shown in drawing appears
[0048] In permanent magnet rotation electrical machinery, since the permanent magnet has always generated magnetic flux irrespective of the existence of the energization to rotation electrical machinery, a rotator always receives the force according to the physical relationship of the stator salient pole section 6 and the pole piece section 15. If a rotator rotates when a mutual position changes, the force which a rotator receives changes in pulsation, and this will serve as cogging torque and torque pulsation, and will appear. Torque pulsation is so remarkable that change of the flux density distribution in a rotator hoop direction is rapid.
[0049] Then, an opening 14 is formed like this operation form, and change of a flux density distribution is made loose. Of an opening 14, the bridge section 17 is formed between the auxiliary magnetic pole section 16 on the front face of a rotator, and the pole piece section 15, and distance is established between the pole piece section 15 and the auxiliary magnetic pole 16 by it. Therefore, compared with the former, change of a loose flux density distribution appears like the graph of drawing 4 , and cogging torque and torque pulsation can be suppressed.
[0050] Moreover, with the rotation electrical machinery with which the hand of cut has become settled only in Mukai on the other hand, you may form the magnetic opening 14 only in the hoop-direction end of a permanent magnet 9.
[0051] In addition, although the permanent magnet 9 of a rectangular parallelepiped as shown in drawing is used in this operation form, the same effect is acquired even if it forms the same opening 14 as other things of a configuration, for example, an arc form and a trapezoid thing.
[0052] Other operation forms of this invention are shown in drawing 6 or drawing 8 .
[0053] Drawing 6 and the operation form of drawing 7 change the configuration of the opening 14 of the operation form in drawing 2 .
[0054] the operation form of drawing 6 -- permanent magnet insertion -- a crevice is established in the bottom of a hole 10 and a permanent magnet 9 is arranged to this crevice Consequently, the rotator radial thickness of an opening 14 is formed smaller than the rotator radial thickness of a permanent magnet 9, and as shown in drawing, the field by the side of the wastepaper constant child of an opening 14 is formed in stator approach rather than the field by the side of the wastepaper constant child of

a permanent magnet 9.
[0055] these -- a permanent magnet 9 -- permanent magnet insertion -- it can position to the position of a hole 10
[0056] Moreover, for positioning of a permanent magnet 9, even if it arranges or fills up an opening 14 with a non-magnetic material, the same effect can be acquired. For example, by arranging the solid-state which changes from a non-magnetic material to an opening 14, and making one fix with a varnish and adhesives, it is stabilized more and a permanent magnet 9 can be arranged.
[0057] Moreover, the operation form of drawing 7 makes hoop-direction width of face of the field by the side of the stator of an opening 14 larger than the hoop-direction width of face of the field by the side of a wastepaper constant child. Especially in drawing 7 , it forms so that the hoop-direction cross section of an opening 14 may become abbreviation triangle-like. By this, the magnetic flux which passes along the auxiliary magnetic pole section 16 can go a permanent magnet 9 around smoothly, and more reluctance torque can be acquired.
[0058] Furthermore, in drawing 6 and the operation form of drawing 7 , the field by the side of the stator of an opening 14 is formed so that it may become abbreviation parallel on the stator side front face of a rotator 2.
[0059] By this, the magnetic saturation of the bridge section 17 becomes tight, and the magnetic flux generated from a permanent magnet 9 can suppress the magnetic flux revealed to the auxiliary magnetic pole section 16 through the pole piece section 15 and the bridge section 17.
[0060] The operation form of drawing 8 changes the configuration of a rotator 2 conversely in order to obtain the same composition. That is, it is constituted so that the bridge section 17 may be extended to an abbreviation perpendicular at inclined plane 14a of an opening 14. The centrifugal force applied to the pole piece section 15 and a permanent magnet 9 by this by the inclination of the bridge section 17 to radial [of a rotator 2] becoming large is supportable with the hauling force of the bridge section 17. Generally the endurance of material has the endurance higher than the above-mentioned operation form in which it is higher to pull [rather than] to shearing force and to receive the force, and the bridge section 17 makes a right angle mostly to radial [of a rotator 2] over a centrifugal force. Therefore, the bridge section 17 is formed more thinly, it is also possible to raise the amount of effective magnetic flux generated from a permanent magnet 9, and a rotator can be rotated more at high speed.
[0061] Other operation forms of this invention are shown in drawing 9 or drawing 11 .
[0062] These form the magnetic opening 14 between the pole piece section 15 and the auxiliary magnetic pole section 16, and an opening 14 is formed in the ends of the pole piece section 15 as shown in drawing. This opening 14 is extended to shaft orientations along the stator side hoop-direction edge of a permanent magnet 9. Of this opening 14, the bridge section 17 as shown in drawing is formed, the flux density distribution in the portion changes gently, and it becomes possible to suppress cogging torque.
[0063] Furthermore, by drawing 9 or drawing 11 , it forms so that an opening 14 may touch the hoop-direction edge of the field by the side of the stator of a permanent magnet 9 and it may enter inside from the hoop-direction end face of a permanent magnet 9. Moreover, at drawing 10 , it forms so that an opening 14 may be extended toward the inside of a permanent magnet 9, and by drawing 11 , it forms so that an opening 14 may be extended in the shape of a rectangle inside a permanent magnet 9.
[0064] When the magnetic flux revealed to the auxiliary magnetic pole section 16 decreases by this and the flux density in the pole piece section 15 increases, efficiency can be raised as rotation electrical machinery. Other operation forms of this invention are shown in drawing 12 or drawing 14 .
[0065] When rotating the rotator of a permanent magnet embedded structure at high speed, the centrifugal force which a permanent magnet receives increases and the burden of the member 15 which supports a permanent magnet, i.e., the pole piece section, and the bridge section 17 increases. When it corresponds to the burden and this member is prepared thickly, the distance of a rotator front face and a permanent magnet is large and a bird clapper and magnetic flux are revealed to the auxiliary magnetic pole section 16, the problem that the magnetic flux transmitted from a permanent magnet to a stator decreases, and torque decreases arises.
[0066] Then, the magnetic opening 14 extended to shaft orientations in a cross section like drawing 12 is formed in the hoop-direction ends of the field by the side of the stator of a permanent magnet 9, and the pole piece supporter material 18 is inserted in shaft orientations, and it fixes to the pole piece section 15 and the auxiliary magnetic pole section 16 so that an opening 14 may be pinched. Drawing 13 is the example of the pole piece supporter material 18, and is taken as the nonmagnetic resin which carried out the typeface of KO here. The axial sectional view of permanent magnet rotation electrical machinery with the rotator 2 by which the pole piece supporter material 18 was inserted in drawing 14 from the both sides of a rotor core 8 is shown.
[0067] An opening 14 suppresses the magnetic flux revealed from the pole piece section 15 to the auxiliary magnetic pole section 16 here. Moreover, the pole piece supporter material 18 works as a medium for having the auxiliary magnetic pole section 16 and supporting the centrifugal force of the permanent magnet 9 concerning the pole piece section 15, and pole piece section 15 self. This can raise the bearing power of a permanent magnet to a centrifugal force.
[0068] Furthermore, the magnetic leakage flux by the bridge section 17 can also be decreased, maintaining the bearing power of the pole piece section 15 by the pole piece supporter material 18 by cutting the bridge section 17 in drawing 12 after the assembly of a rotator 2.
[0069] Other operation forms of this invention are shown in drawing 15 .
[0070] Here, as shown in drawing, the magnetic opening 14 is formed between the pole piece section 15 and the auxiliary magnetic pole section 16, and the permanent magnet supporter material 19 which combined the magnetic material and the non-magnetic material between a permanent magnet 9 and the pole piece section 15 is formed.
[0071] The permanent magnet supporter material 19 is the combination of magnetic material 19a and non-magnetic material 19b, as shown in drawing, and it joins both by welding etc. Magnetic material 19a is constituted from material of the magnetic substance, in order to transmit the generating magnetic flux of a permanent magnet 9 to the pole piece section 15, and non-magnetic material 19b consists of material of non-magnetic material, in order to suppress the magnetic leakage flux from the permanent magnet 9 to the auxiliary magnetic pole section 16.
[0072] By the above composition, the centrifugal force concerning a permanent magnet 9 can be supported in the auxiliary magnetic pole section 16 through the permanent magnet supporter material 19, and the centrifugal force of the pole piece section 15 serves as this chisel at the bridge section 17. Therefore, the radial length of the bridge section 17 can be shortened, therefore magnetic-flux disclosure from a permanent magnet 9 can be lessened.
[0073] Or it is also effective to set in drawing 9 or the operation form of drawing 11 , and to arrange or fill up an opening 14 with a non-magnetic material.
[0074] The thickness of the pole piece section 15 is set as thickness required in order to acquire sufficient magnetic flux, an

opening 14 is pierced in drawing 9 or a configuration like drawing 11 to the stator side of a permanent magnet 9, and it considers as the composition filled up with a nonmagnetic material, for example, adhesives, and a varnish there. The centrifugal force which a permanent magnet 9 and the pole piece section 15 receive can be supported by the opening 14, without making the pole piece section 15 thick to radial by this.
[0075] Moreover, it is also possible as a material of a permanent magnet 9 to use a resin magnet. in this case, instead of [of a nonmagnetic material with which an opening 14 is filled up] -- a resin magnet -- permanent magnet insertion -- it can insert in in the configuration where the opening 14 was doubled with the hole 10 That is, it becomes possible to make the plastics magnet itself serve as the above roles of an opening 14. Furthermore, it is also more effective than the hoop-direction width of face of a permanent magnet 9 like drawing 16 to prepare greatly the hoop-direction width of face of the auxiliary magnetic pole section 16.

[0076] The weight of the permanent magnet 9 which makes the centrifugal force concerning the bridge section 17 by this can be mitigated, thickness of the bridge section 17 can be made smaller, and the magnetic flux revealed to the auxiliary magnetic pole section 16 from the pole piece section 15 can be decreased.
[0077] In addition, the hoop-direction width of face of a permanent magnet 9 is small, and although the magnetic flux generated from a permanent magnet 9 by the bird clapper decreases, the reluctance torque by the auxiliary magnetic pole section 16 increases relatively. This is effective when a neodium magnet expensive as a permanent magnet 9 is used, and improvement in cost performance can be aimed at by compensating the part of the cost cut by reducing the amount of a permanent magnet 9 with the reluctance torque of the auxiliary magnetic pole section 16.
[0078] In addition, if the permanent magnet rotation electrical machinery described above is applied to electric vehicles, especially an electric vehicle, there can be little cogging torque, can carry the stable permanent magnet rotation electrical machinery driving gear which can depart smoothly, and can offer an electric vehicle with long 1 charge mileage.
[0079]
[Effect of the Invention] According to invention according to claim 1, permanent magnet rotation electrical machinery with little torque throb can be constituted.
[0080] According to a claim 2 and invention according to claim 3, in addition to the same effect as a claim 1, positioning of a permanent magnet is attained.
[0081] According to a claim 4 and invention according to claim 5, it is possible to constitute so that the magnetic flux which passes along an auxiliary magnetic pole further may go a permanent magnet around smoothly.
[0082] According to a claim 6 and invention according to claim 7, it becomes possible further to suppress the magnetic flux revealed from the member by the side of the stator of an opening to an auxiliary magnetic pole from a permanent magnet.
[0083] Moreover, permanent magnet rotation electrical machinery with little torque throb is realizable with invention according to claim 8.
[0084] According to a claim 9 or invention according to claim 11, in addition to the same effect as a claim 8, the magnetic flux revealed to the auxiliary magnetic pole section from the field by the side of the stator of a permanent magnet can be suppressed.

[0085] Furthermore, according to a claim 12 or invention according to claim 16, in addition to the effect of reduction of torque throb, the bearing power to the centrifugal force concerning a permanent magnet is securable.
[0086] According to invention according to claim 17, electric vehicles with the stable driving gear with little cogging torque can be offered.

[Translation done.]

DESCRIPTION OF DRAWINGS

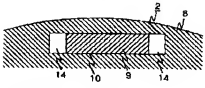
[Brief Description of the Drawings]
[Drawing 1] The hoop-direction cross section of the permanent magnet rotation electrical machinery which makes 1 operation gestalt of this invention.
[Drawing 2] The enlarged view of the permanent magnet circumference with the arbitrary rotator of drawing 1 .
[Drawing 3] The axial sectional view of the operation gestalt of drawing 1 .
[Drawing 4] the rotator of drawing 2 -- the functional description view of a member, and a flux density distribution
[Drawing 5] the rotator of the conventional permanent magnet rotation electrical machinery -- the functional description view of a member, and a flux density distribution
[Drawing 6] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 7] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 8] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 9] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 10] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 11] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 12] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 13] The perspective diagram of the pole piece supporter material of drawing 12 .
[Drawing 14] The axial sectional view of the permanent magnet rotation electrical machinery of drawing 12 .
[Drawing 15] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Drawing 16] The hoop-direction cross section of the rotator of the permanent magnet rotation electrical machinery which makes other operation gestalten of this invention.
[Description of Notations]
1 -- stator and 2 -- -- a rotator, 3 -- stator core, 4 -- stator winding, and 5 -- -- the core section, 6 -- stator salient pole section, 7 -- shaft, and 8 -- -- a rotor core, 9 -- permanent magnet, and 10 -- permanent magnet insertion -- a hole, 11 -- housing, 12 -- and a bracket, 13 -- bearing, and 14 -- -- an opening, 15 -- pole piece section, the 16 -- auxiliary magnetic pole section, and 17 -- -- the bridge section, 18 -- pole piece

[Translation done.]

DRAWINGS

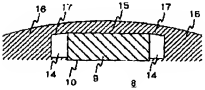
[Drawing 2]

図 2



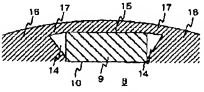
[Drawing 6]

図 6



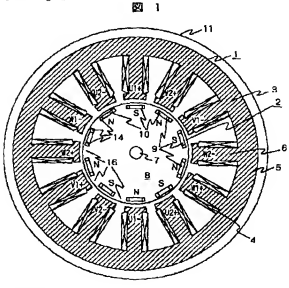
[Drawing 7]

図 7



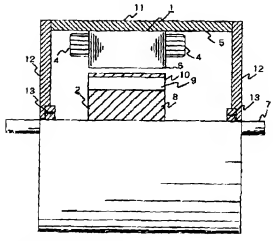
[Drawing 1]

図 1



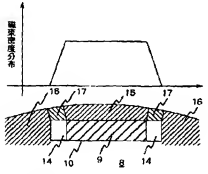
[Drawing 3]

図 3



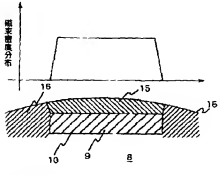
[Drawing 4]

図 4



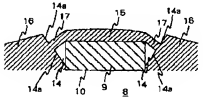
[Drawing 5]

図 5



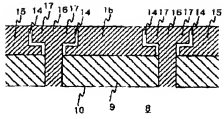
[Drawing 8]

図 8



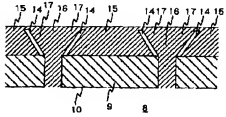
[Drawing 9]

図 9



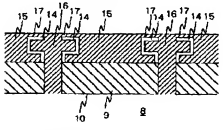
[Drawing 10]

図 10



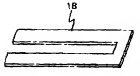
[Drawing 11]

図 11



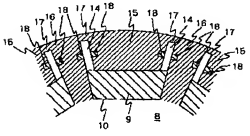
[Drawing 13]

図 13



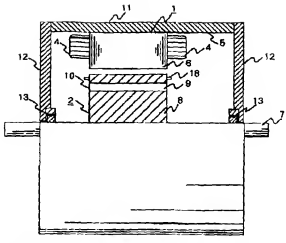
[Drawing 12]

図 12



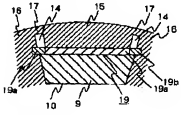
[Drawing 14]

図 14



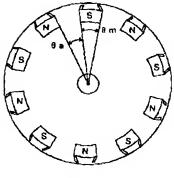
[Drawing 15]

図 15



[Drawing 16]

図 16



[Translation done.]

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[FI]

H02K 1/27 501 A .

[Procedure revision]
[Filing Date] October 31, Heisei 12 (2000. 10.31)
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[Document to be Amended] Specification.
[Item(s) to be Amended] Claim.
[Method of Amendment] Change.
[Proposed Amendment]
[Claim(s)]
[Claim 1] Permanent magnet rotation electrical machinery characterized by providing the following. Stator. The rotator arranged through an opening at the inner circumference side of this stator. two or more permanent magnet insertion annularly arranged while being formed in this rotator -- a hole these permanent magnet insertion of two or more -- the auxiliary magnetic pole section prepared between the permanent magnet embedded at the hole, and the aforementioned permanent magnet which adjoins a hoop direction while being formed in the aforementioned rotator -- having -- an opening magnetic between the aforementioned permanent magnet and the aforementioned auxiliary magnetic pole section
[Claim 2] Permanent magnet rotation electrical machinery characterized by providing the following. Stator. The rotator arranged through an opening at the inner circumference side of this stator. two or more permanent magnet insertion annularly arranged while being formed in this rotator -- a hole these permanent magnet insertion of two or more -- the auxiliary magnetic pole section prepared between the permanent magnet embedded at the hole, and the aforementioned permanent magnet which adjoins a hoop direction while being formed in the aforementioned rotator, and the pole piece section arranged at the aforementioned stator side of the aforementioned permanent magnet -- having -- an opening magnetic between the aforementioned auxiliary magnetic pole section and the aforementioned pole piece section
[Claim 3] Permanent magnet rotation electrical machinery characterized by preparing nonmagnetic material in the aforementioned opening in permanent magnet rotation electrical machinery according to claim 1 or 2.
[Claim 4] It is the permanent magnet rotation electrical machinery characterized by being the thing which the aforementioned opening makes [thing] change of a flux density distribution loose in permanent magnet rotation electrical machinery according to claim 1 or 2, and makes cogging torque suppress.
[Claim 5] They are the electric vehicles characterized by the aforementioned driving gear having permanent magnet rotation electrical machinery according to claim 1 to 4 in the electric vehicles equipped with the driving gear.

[Translation done.]

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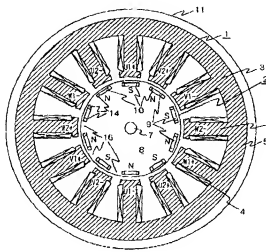
最終頁に続く

(54)【発明の名称】　永久磁石回転電機および永久磁石回転電機を用いた電動車両

(57)【要約】
【課題】補助磁極によるリラクタンストルクを得ながら、コギングトルクやトルク脈動を抑えた永久磁石回転電機、およびそれを用いた電動車両を提供する。
【解決手段】回転子の永久磁石と、該永久磁石に周方向に隣り合った補助鉄極との間に磁気的な空隙を設けることにより、回転子の表面の磁束密度分布変化を緩やかにし、コギングトルクやトルク脈動を抑える。

図　1



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【特許請求の範囲】

【請求項1】固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記永久磁石と、前記永久磁石に周方向に隣り合った前記補助磁極部との間に磁気的な空隙を設けたことを特徴とする永久磁石回転電機。

【請求項2】請求項1に記載の永久磁石回転電機において、前記永久磁石挿入孔の底に凹部を設け、該凹部に前記永久磁石を配置したことを特徴とする永久磁石回転電機。

【請求項3】請求項1または請求項2に記載の永久磁石回転電機において、前記空隙に非磁性材料を配置したことを特徴とする永久磁石回転電機。

【請求項4】請求項1ないし請求項3のいずれかに記載の永久磁石回転電機において、前記空隙の固定子側の面の周方向幅よりも磁空隙の反固定子側の面の周方向幅よりも大きくしたことを特徴とする永久磁石回転電機。

【請求項5】請求項4に記載の永久磁石回転電機において、前記空隙の周方向断面は三角形状であることを特徴とする永久磁石回転電機。

【請求項6】請求項1ないし請求項5のいずれかに記載の永久磁石回転電機において、前記磁極片部はフリッシ部を介して前記補助磁極に接続され、前記フリッシ部の固定子側表面と空隙側表面は略平行であることを特徴とする永久磁石回転電機。

【請求項7】請求項6に記載の永久磁石回転電機において、前記フリッシ部は、前記空隙の傾斜面に垂直に伸びるよう形成したことを特徴とする永久磁石回転電機。

【請求項8】固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空隙を設けたことを特徴とする永久磁石回転電機。

【請求項9】請求項8に記載の永久磁石回転電機において、前記空隙は前記永久磁石の固定子側の面の周方向端部に接することを特徴とする永久磁石回転電機。

【請求項10】請求項9に記載の永久磁石回転電機において、前記空隙は前記永久磁石の内側に伸びていることを特徴とする永久磁石回転電機。

【請求項11】請求項9に記載の永久磁石回転電機において、前記空隙は前記永久磁石の内側に矩形状に伸びていることを特徴とする永久磁石回転電機。

【請求項12】固定子鉄心に巻線を施した固定子と、間

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に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空隙を設け、非磁性の磁極片支持部材により前記磁極片部を前記補助磁極部に固定せしめたことを特徴とする永久磁石回転電機。

【請求項13】請求項12に記載の永久磁石回転電機において、前記磁極片支持部材はコの字形状かつ前記回転子鉄心の両軸から挿入されていることを特徴とする永久磁石回転電機。

【請求項14】固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空隙を設け、前記磁極片部と前記永久磁石の間に磁性材料と非磁性材料を端台合わせた永久磁石支持部材を配置し、かつ前記永久磁石支持部材の前記磁性材料を前記磁極片部と前記永久磁石間に配置し、前記非磁性材料を前記補助磁極部に係合させたことを特徴とする永久磁石回転電機。

【請求項15】請求項8ないし請求項14のいずれかに記載の永久磁石回転電機において、前記空隙に非磁性材料を配置したことを特徴とする永久磁石回転電機。

【請求項16】請求項1ないし請求項15のいずれかに記載の永久磁石回転電機において、前記永久磁石の周方向幅は前記補助磁極部の周方向幅よりも小さいことを特徴とする永久磁石回転電機。

【請求項17】請求項1ないし請求項16のいずれかに記載の永久磁石回転電機により駆動される電動車両。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は回転電機および回転電機を用いた電動車両に係り、特に磁束発生手段として永久磁石を用いた永久磁石回転電機、および永久磁石回転電機を用いた電動車両に関する。

【0002】

【従来の技術】従来より回転電機の一種として、回転子の磁界発生手段に永久磁石を用いた永久磁石回転電機が使用されている。

【0003】従来の永久磁石回転電機としては、表面磁石構造、すなわち隣接する永久磁石が周方向に逆極性となるように、回転子の表面に複数の永久磁石を並置、固定したものがある。

【0004】しかし、表面磁石構造のものは、遠心力により高速回転時に永久磁石が剥離する可能性が高いことから、回転子内の軸方向へ伸びる孔に永久磁石を挿入、

固定した永久磁石埋め込み構造の永久磁石回転子が特開平5－76146号公報に開示されている。

【０００５】また永久磁石埋め込み構造の回転子にスキューを施す場合の構成を簡素にすることを目的として、回転子内部に設置した各永久磁石の端面から回転子の外周へ空隙を形成したものが特開平5－236687号公報に開示されている。

【０００６】

【発明が解決しようとする課題】しかし、上記の従来技術では、補助磁極によるリラクタンストルクを得ることと、コギングトルクまたはトルク脈動（以下、両者を併せて「トルク脈動」と言う）の減少を両立できないという問題がある。

【０００７】永久磁石埋め込み構造の回転子では、隣接した永久磁石間の回転子部材を補助磁極として利用し、固定子の電機子起磁力の合成ベクトルをこの補助磁極の中心位置より回転方向側に向くように制御することにより、リラクタンストルクを得ることができる。このリラクタンストルクは、永久磁石による主トルクに加算され、回転電機の総トルクを増加し、効率を高めるものである。

【０００８】一方、永久磁石回転電機においては、通電の有無にかかわらず常に磁束を発生している永久磁石を用いるため、回転子は常に永久磁石と固定子突極部との位置関係に応じた力を受け、回転時にはその力が脈動的に変化する。それがトルク脈動となって現れる。これは回転子のスムーズな回転を妨げ、回転電機として安定した動作を得ることができないという問題を生じる。

【０００９】特開平5－76146号公報に記載されている永久磁石回転子は、補助磁極を有していることから、リラクタンストルクを得ることは可能であるが、永久磁石と補助磁極との距離が周方向に微小であることから、そこに磁束密度分布の急激な変化が現れ、トルク脈動が生じる。

【００１０】特開平5－236687号公報に開示されている永久磁石回転電機は、永久磁石間に空隙が設けられていること、または空隙に非磁性体からなる接着性の充填材が充填されていることによって、隣り合った永久磁石間の磁束密度分布変化が緩やかとなり、コギングトルクまたはトルク脈動は発生し辛くいが、この空隙または充填材は補助磁極の役目を果たさないので、リラクタンストルクを得ることができない。

【００１１】本発明は上記事情に鑑みて、補助磁極によるリラクタンストルクを得ながら、トルク脈動を抑えることのできる永久磁石回転電機、およびそれを用いた電動車両を提供することを目的とする。

【００１２】

【課題を解決するための手段】請求項１に記載の発明は、固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に回転空隙をもって配置した永久磁石回転電機において、前記永久磁石と、前記永久磁石に周方向で隣り合った前記補助磁極部との間に磁気的な空隙を設けたことを特徴とする。

【００１３】この磁気的な空隙は、回転子の周方向における永久磁石と補助磁極間の磁束密度分布変化を緩やかにし、トルク脈動を減少させるものである。よってこの空隙は、単なる空間であってもよいし、非磁性材料を配置または充填したものであってもよい。

【００１４】またこの空隙は、永久磁石の両端にあってもよく、また回転電機の回転方向やその用途によっては、永久磁石の周方向のどちらか一端のみにあってもよい。

【００１５】しかし上記空隙を永久磁石の周方向端部に設けることにより、高速回転時などに磁石の位置決めが不安定になる可能性がある。そこで請求項２に記載のように、前記永久磁石挿入孔の底に凹部を設け、該凹部に前記永久磁石を配置する、または請求項３に記載のように、前記空隙に非磁性材料を配置させることで、永久磁石を位置決めすることが可能である。

【００１６】また前記空隙は、固定子に対する磁束密度分布変化を緩やかにするものであれば足りることから、その形状を変化させることにより、補助磁極の作用を補助することも可能である。すなわち請求項４に記載のように、前記空隙の固定子側の面の周方向幅を該空隙の反固定子側の面の周方向幅よりも大きくする、または請求項５に記載のように、前記空隙の周方向断面を三角形状になるよう構成することにより、補助磁極の磁束が永久磁石を周回し易いように構成することも可能であり、より多くのリラクタンストルクを得ることができる。

【００１７】さらには、請求項６に記載のように、前記磁極片部はブリッジ部を介して前記補助磁極に接続され、前記ブリッジ部の固定子側表面と空隙側表面を略平行に形成する、または請求項７に記載のように、前記ブリッジ部は前記空隙の幅を両に垂直に伸びるより形成することにより、永久磁石から空隙の固定子側の面付近の部材から補助磁極へ漏洩する磁束を抑えることが可能である。

【００１８】特に請求項７に記載の発明によれば、永久磁石にかかる遠心力をブリッジ部の引っ張り力によって支えることができ、より高速回転かつ可能な永久磁石回転電機を提供できる。

【００１９】請求項８に記載の発明は、固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記固定子と回転空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空

隙を設けたことを特徴とする。

【0020】この磁気的な空隙も、請求項1に記載の発明と同様に、回転子の周方向における永久磁石と補助磁極間の磁束密度分布変化を緩やかにし、トルク脈動を減少させる。

【0021】また、請求項9に記載のように前記空隙を前記永久磁石の固定子側の面の周方向端部に接するよう、または請求項10に記載のように前記空隙を前記永久磁石の内側に伸びるよう、若しくは請求項11に記載のように前記空隙を前記永久磁石の内側に矩形状に伸びるよう形成することによって、永久磁石の固定子側の面から補助磁極部に漏洩する磁束を抑えることが可能である。

【0022】しかし、インナロータ型の回転電機において、永久磁石の固定子側にある磁極片部に空隙を設けることは、高速回転時に、永久磁石への遠心力に対する支持力を損なわせる可能性がある。

【0023】そこで請求項12に記載のように、固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に同軸空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空隙を設け、非磁性の磁極片支持部材により前記磁極片部を前記補助磁極部に固定せしめること、または請求項13に記載のように、前記磁極片支持部材はコの字形状かつ前記固転子鉄心の両軸から挿入されていることにより、磁極片部にかかる永久磁石の遠心力を補助磁極部で支えることができる。

【0024】また、請求項14に記載のように、固定子鉄心に巻線を施した固定子と、間に補助磁極部を介しかつ固定子側に磁極片部を形成する複数個の永久磁石挿入孔を環状に形成し、かつ該永久磁石挿入孔に永久磁石を埋め込んだ回転子とから構成され、さらに前記回転子を前記固定子に同軸空隙をもって配置した永久磁石回転電機において、前記磁極片部と前記補助磁極部との間に磁気的な空隙を設け、前記磁極片部と前記永久磁石の間に磁性材料と非磁性材料を組み合わせた永久磁石支持部材を配置し、かつ前記永久磁石支持部材の前記磁性材料を前記磁極片部と前記永久磁石間に配置し、前記非磁性材料を前記補助磁極部に係合させることによっても、同様に永久磁石の受ける遠心力に対する支持力を増加させることができる。

【0025】さらには　請求項15に記載のように、前記実施に非磁性材料を配置することによっても、永久磁石の受ける遠心力に対する支持力を増加させることができる。

【0026】また請求項16に記載のように、前記永久磁石の周方向幅を前記補助磁極部の周方向幅よりも小さくすることによっても、永久磁石にかかる遠心力を有効に軽減することができる。

【0027】請求項17に記載の発明は、請求項1ないし請求項16に記載の永久磁石回転電機により駆動される電動車両であり、コギングトルクの少ない、安定した駆動装置を持つ電動車両を提供することができる。

【0028】なお、上記回転電機は、発電機及び電動機、インドロータ及びアウタロータ、回転型及びリニア型、巣中巻及び分布巻き固定子構造のいずれのものであっても、本発明を適用可能である。

【0029】また上記全ての発明は、永久磁石の形状に依存せず、直方体、アーク形、台形等　とのようなものでも適用可能であり、同様の効果を奏する。

【0030】

【発明の実施の形態】以下、本発明の実施形態を図を用いて詳細に説明する。

【0031】図1は本発明の一実施形態であるインナロータ型集中巻固定子構造の永久磁石回転電機の周方向断面図を示す。

【0032】回転電機は固定子1と回転子2から構成され、これらは図のように互いに同軸空隙をもって配置される。

【0033】固定子1は、固定子鉄心3と固定子巻線4からなり、固定子鉄心3は更にコア部5と固定子突極部6とから構成される。コア部5には固定子突極部6に巻束を通すための磁気回路が形成され、固定子突極部6には固定子巻線4が集中的に巻回される。

【0034】回転子2はシャフト7、回転子鉄心8、および永久磁石9からなる。回転子鉄心8には、永久磁石9を挿入する永久磁石挿入孔10およびシャフト7を通す孔が軸方向に打ち抜かれ、それぞれ永久磁石9およびシャフト7が挿入、固定される。

【0035】このように本実施形態はいわゆる永久磁石埋め込み構造のものであり、永久磁石9を回転子2に環状に配置することによって、互いに隣接する永久磁石挿入孔10の間の部材を補助磁極部16として機能させることができる。

【0036】すなわち、図示しない制御装置によって、固定子巻線4による電機子起磁力の合成ベクトルを補助磁極の中心位置より回転方向側に向くように制御すれば、固定子巻線4から発生した磁束が補助磁極部16を介して永久磁石9を周回し、リラクタンストルクが発生する。これは特に低速運転状態において有効であり、上記リラクタンストルクが永久磁石9による通常のトルクに加わることで、電動機として高いトルクを得ることができる。

【0037】図3は本実施形態に係る永久磁石回転電機の軸方向の断面構造を示す。

【0038】固定子1はハウジング11の内周面に図のように固定され、また回転子2に挿入、固定されたシャ

ット7は、回転子2が固定子1に回転空隙をもって回転自在に接するよう、ベアリング13およびエンドブラケット12によって固定子1に保持される。

【0039】本実施形態では、回転子鉄心8の材料として永久磁石9よりも高い透磁率を有するもの、例えば珪素鋼板のような高透磁率磁性材料を用いる。これにより、磁石内部に発生する渦電流損を減少させることができ、また前述の補助磁極部16をより有効に機能させることができる。

【0040】なお本発明は、発電機及び電動機、インナーロータ及びアウターロータ、回転型及びリニア型、集中巻き及び分布巻き固定子構造のいずれにおいても適用可能であり、同様の効果が得られる。

【0041】本実施形態は、永久磁石9と、該永久磁石9に周方向に隣り合った補助磁極部16との間に磁気的な空隙14を設けるものである。

【0042】図2に図1における任意の永久磁石9の周辺を拡大した図を示す。図のように、永久磁石9の周方向端部に空隙14を設けるように永久磁石挿入孔10を形成し、そこに永久磁石9を挿入、固定する。この空隙は軸方向に伸び、永久磁石9と補助磁極部16に接している。

【0043】この空隙14の作用を図4および図5を用いて説明する。

【0044】図4および図5は、永久磁石9周辺の周方向断面図と、永久磁石9に従って回転子20の周表面から発生される磁束密度分布の関係を表した図である。図4は前述の実施形態を用いた回転子を、図5は従来の回転子を示す。

【0045】双方とも、回転子鉄心8の磁極片部15は、永久磁石9が発生した磁束を固定子1へ伝達する部材として機能する。また隣り合った永久磁石挿入孔10の間の部材、すなわち図中の補助磁極部16はリラクタンストルクを発生する補助磁極として機能する。

【0046】図4および図5の上部にあるグラフは、永久磁石9によって回転子2の固定子側表面から発生される磁束密度分布を表している。両図ともに、磁極片部15では、永久磁石9の発生する磁束はほぼ一定の磁束密度分布を示す。一方、補助磁極部16では、永久磁石9による磁束が伝達されにくく、回転子2の固定子側表面から発生される磁束はほぼ零となる。

【0047】しかし、従来の回転子においては、図5のように回転子鉄心8に設けられた永久磁石挿入孔10全体を埋めるように永久磁石9が配置されていることから、磁極片部15と補助磁極部16の境界付近において図のような急激な磁束密度分布の変化が現れる。

【0048】永久磁石回転電機においては、回転電機への通電の有無にかかわらず、永久磁石が常に磁束を発生しているため、回転子は、常に固定子突極部6と磁極片部15との位置関係に応じた力を受ける。回転子が回転すれば、互いの位置が変化することにより回転子の受ける力が脈動的に変化し、これがコギングトルクやトルク脈動となって現れる。回転子周方向における磁束密度分布の変化が急激なほど、トルク脈動は顕著である。

【0049】そこで本実施形態のように空隙14を設け、磁束密度分布の変化を緩やかなものにする。空隙14によって、回転子表面の補助磁極部16と磁極片部15の間にフリッジ部17が形成され、磁極片部15と補助磁極16の間に距離が設けられる。従って、図4のグラフのように従来に比べて緩やかな磁束密度分布の変化が現れ、コギングトルクやトルク脈動を抑制することができる。

【0050】また、回転方向が一方向のみに定まっている回転電機では、永久磁石9の周方向一端にのみ磁気的な空隙14を設けても良い。

【0051】なお本実施形態においては図のような直方体の永久磁石9を用いているが、他の形状のもの、例えばブーク形や台形のものに同様の空隙14を形成しても同様の効果が得られる。

【0052】図6ないし図8には、本発明の他の実施形態を示す。

【0053】図6および図7の実施形態は図2における実施形態の空隙14の形状を変化させたものである。

【0054】図6の実施形態は、永久磁石挿入孔10の底に凹部を設け、該凹部に永久磁石9を配置したものである。その結果、空隙14の回転子半径方向の厚さは永久磁石9の回転子半径方向の厚さよりも小さく形成され、図のように空隙14の反固定子側の面が永久磁石9の反固定子側の面よりも固定子寄りに形成される。

【0055】これらにより永久磁石9を永久磁石挿入孔10の所定の位置に位置決めすることができる。

【0056】また永久磁石9の位置決めのためには、空隙14に非磁性材料を配置または充填しても同様の効果を得ることができる。例えば空隙14に非磁性材料から成る固体を配置し、一体にワニス及び接着剤で固着させることによって、永久磁石9をより安定して配置することができる。

【0057】また図7の実施形態は、空隙14の固定子側の面の周方向幅を反固定子側の面の周方向幅よりも大きくしたものである。図7では特に空隙14の周方向断面が略二角形状となるように形成する。このことによって、補助磁極部16を通る磁束がスムーズに永久磁石9を周回することができ、リラクタンストルクをより多く得ることができる。

【0058】さらに図6および図7の実施形態においては、回転子2の固定子側表面に略平行となるように空隙14の固定子側の面を形成する。

【0059】これによって、フリッジ部17の磁気的な結合はきつくなり、永久磁石9から発生する磁束が磁極片部15、フリッジ部17を介して補助磁極部16に漏

護する磁束を抑制することができる。

【0060】図8の実施形態は、同様の構成を得るため、逆に回転子20の形状を変更したものである。すなわちブリッジ部17が空隙14の傾斜面14aに距離的に伸びるよう構成される。このことにより、回転子2の半径方向に対するブリッジ部17の幅さが大きくなり、磁極片部15及び永久磁石9にかかる遠心力をブリッジ部17の引っ張り力により支えることができる。一般的に材料の耐久性は、剪断力に対するよりも引っ張り力に対する方が高く、ブリッジ部17が回転子2の半径方向に対してほぼ直角な従来の実施形態よりも遠心力に対する耐久性が高い。従ってブリッジ部17をより薄く形成し、永久磁石9から発生する有効磁束量を高めることも可能であり、またより高速に回転子を回転することができる。

【0061】図9ないし図11に本発明の他の実施形態を示す。

【0062】これらは、磁極片部15と補助磁極部16の間に磁気的な空隙14を設けるものであり、図のように磁極片部15の両端に空隙14が形成される。この空隙14は、永久磁石9の固定子側周方向端部に沿って軸方向に伸びている。この空隙14により、図のようなフリッジ部17が形成され、その部分における磁束密度分布が緩やかに変化し、コギングトルクを抑制することが可能となる。

【0063】さらに図9ないし図11では、空隙14が永久磁石9の固定子側の面の周方向端部に接し、かつ永久磁石9の側方両端部より内へ入り込むように形成する。また図10では空隙14が永久磁石9の内側に向かって伸びるように形成し、図11では空隙14が永久磁石9の内側に矩形状に伸びるように形成する。

【0064】このことにより、補助磁極部16に漏洩する磁束が減少し、磁極片部15における磁束密度が高まることにより、回転電機として効率を高めることができる。図12ないし図14に、本発明の他の実施形態を示す。

【0065】永久磁石埋め込み構造の回転子を高速に回転させたとき、永久磁石の受ける遠心力が増加し、永久磁石を支持する部材、すなわち磁極片部15やブリッジ部17の負担が増加する。その負担に対応し、該部材を厚く設けた場合、回転子表面と永久磁石との距離が大きくなること、および磁束が補助磁極部16に漏洩することにより、永久磁石から固定子に対して伝達される磁束が減少し、トルクが減少するという問題が生じる。

【0066】そこで、永久磁石9の固定子側の面の周方向両端に図12のような断面で軸方向に伸びる磁気的な空隙14を形成し、空隙14を挟むように磁極片部15と補助磁極部16に磁極片支持部材18を軸方向にはめ込み固定する。図13は磁極片支持部材18の例であり、ここではコの字形をした非磁性の樹脂とする。図14に磁極片支持部材18が回転子鉄心8の両側から差し込まれた回転子2を持つ永久磁石同転磁機の軸方向断面図を示す。

【0067】ここで空隙14は、磁極片部15から補助磁極部16へ漏洩する磁束を抑制する。また磁極片支持部材18は、磁極片部15にかかる永久磁石9および磁極片部15自身の遠心力を、補助磁極部16をもって支えるための媒体として働く。このことにより、遠心力に対する永久磁石の支持力を高めることができる。

【0068】さらには、図12におけるブリッジ部17を回転子2の組立後に切削することにより、磁極片支持部材18により磁極片部15の支持力を維持しながら、ブリッジ部17による漏洩磁束も減少させることができる。

【0069】図15に本発明の他の実施形態を示す。

【0070】ここでは、図のように磁極片部15と補助磁極部16の間に磁気的な空隙14を形成し、永久磁石9と磁極片部15の間に磁性材料と非磁性材料を組み合わせた永久磁石支持部材19を設ける。

【0071】永久磁石支持部材19は、図のように磁性材料19aと非磁性材料19bの組み合せであり、両者は例えば溶接などによって接合する。磁性材料19aは永久磁石9の発生磁束を磁極片部15に伝達するために磁性体の材料で構成し、非磁性材料19bは永久磁石9から補助磁極部16への漏洩磁束を抑制するために非磁性体の材料で構成する。

【0072】以上の構成によって、永久磁石9にかかる遠心力を永久磁石支持部材19を介し補助磁極部16で支持することができ、フリッジ部17には磁極片部15の遠心力がかかるのみとなる。よって、ブリッジ部17の半径方向の長さを短くでき、従って永久磁石9からの磁束漏洩を少なくすることができる。

【0073】あるいは、図9ないし図11の実施形態において、空隙14に非磁性材料を配置または充填することも有効である。

【0074】磁極片部15の厚さを十分な磁束を得るために必要な厚さに設定し、空隙14を永久磁石9の固定子側に図9ないし図11のような形状で打ち抜き、そこに非磁性の材料、例えば接着剤、ワニスを充填する構成とする。このことによって、磁極片部15を半径方向に厚くすることなく、永久磁石9や磁極片部15が受ける遠心力を空隙14によって支えることができる。

【0075】また、永久磁石9の材料として、樹脂磁石を用いることも可能である。この場合、空隙14に充填する非磁性の材料の代わりに、樹脂磁石を永久磁石挿入孔10と空隙14を合わせた形状で成形することができる。すなわちプラスチックマグネット前駆に空隙14の上記のような役割を兼ねさせることが可能となる。さらには、図16のように永久磁石9の側方両端よりも補助磁極部16の周方向幅を大きく設けることも有効であ

る。

【0076】このことにより、フリッジ部17にかかる遠心力を作り出す永久磁石9の重量が軽減され、フリッジ部17の厚さをより小さくすることができ、磁極片部15から補助磁極部16に漏洩する磁束を減少することができる。

【0077】なお、永久磁石9の周方向幅が小さくなることによって、永久磁石9から発生する磁束は減少するが、相対的に補助磁極部16によるリラクタンストルクは増加する。これは永久磁石9として高価なネオジウム磁石を用いた場合などに有効であり、永久磁石9の量を減らすことによるコストダウンの分を、補助磁極部16のリラクタンストルクで補うことにより、コストパフォーマンスの向上を図ることができるものである。

【0078】なお、以上に述べた永久磁石回転電機を電動車両、特に電気自動車に適用すれば、コギングトルクが少なく、スムーズに発進できる安定した永久磁石回転電機駆動装置を搭載でき、一充電走行距離の長い電気自動車を提供することができる。

【0079】

【発明の効果】請求項1に記載の発明によれば、トルク脈動の少ない永久磁石回転電機を構成できる。

【0080】請求項2および請求項3に記載の発明によれば、請求項1と同様の効果に加えて、永久磁石の位置決めが可能となる。

【0081】請求項4および請求項5に記載の発明によれば、さらに補助磁極を巻き線なしスムーズに永久磁石を周回するよう構成することが可能である。

【0082】請求項6および請求項7に記載の発明によれば、さらに永久磁石から空隙の固定子側の部材から補助磁極へ漏洩する磁束を抑えることが可能となる。

【0083】また請求項8に記載の発明によっても、トルク脈動の少ない永久磁石回転電機を実現できる。

【0084】請求項9ないし請求項11に記載の発明によれば、請求項8と同様の効果に加えて、永久磁石の固定子側の面から補助磁極部に漏洩する磁束を抑えることができる。

【0085】さらに請求項12ないし請求項16に記載の発明によれば、トルク脈動の減少という効果に加えて、永久磁石にかかる遠心力に対する支持力を確保することができる。

＊【0086】請求項17に記載の発明によれば、コギングトルクの少ない、安定した駆動装置を持つ電動車両を提供することができる。

【図面の簡単な説明】

【図1】本発明の一実施形態をなす永久磁石回転電機の周方向断面図。

【図2】図1の回転子の任意の永久磁石周辺の拡大図。

【図3】図1の実施形態の軸方向断面図。

【図4】図2の回転子部材の機能説明図と磁束密度分布。

【図5】従来の永久磁石回転電機の回転子部材の機能説明図と磁束密度分布。

【図6】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図7】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図8】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図9】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図10】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図11】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図12】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図13】図12の磁極片支持部材の斜視図。

【図14】図12の永久磁石回転電機の軸方向断面図。

【図15】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【図16】本発明の他の実施形態をなす永久磁石回転電機の回転子の周方向断面図。

【符号の説明】

1…固定子、2…回転子、3…固定子鉄心、4…固定子巻線、5…コア部、6…固定子突極部、7…シャフト、8…回転子鉄心、9…永久磁石、10…永久磁石挿入孔、11…ハウジング、12…エンドブラケット、13…ベアリング、14…空隙、15…磁極片部、16…補助磁極部、17…フリッジ部、18…磁極片支持部材、19…永久磁石支持部材。

【図2】

図 2

【図6】

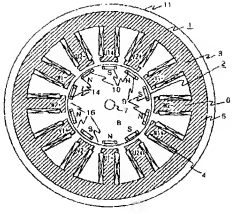
図 6

【図7】

図 7

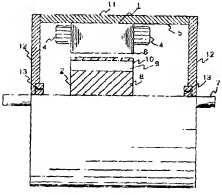
【図１】

図 1



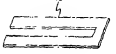
【図３】

図 3



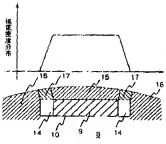
【図１３】

図 13



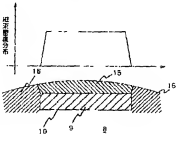
【図４】

図 4



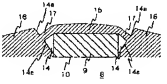
【図５】

図 5



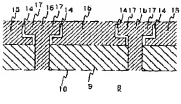
【図８】

図 8



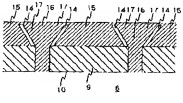
【図９】

図 9



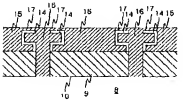
【図１０】

図 10



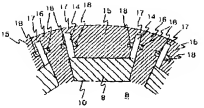
【図１１】

図 11



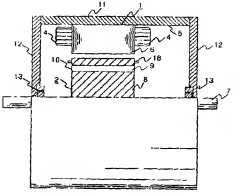
【図12】

図 12



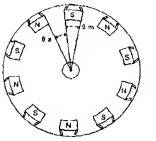
【図14】

図 14



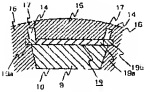
【図16】

図 16



【図15】

図 15



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【提出日】平成１２年１０月３１日（２０００．１０．３１）
【手続補正１】
【補正対象書類名】明細書
【補正対象項目名】特許請求の範囲
【補正方法】変更
【補正内容】
【特許請求の範囲】
【請求項１】固定子と、該固定子の内周側に空隙を介して配置された回転子と、該回転子に形成されると共に周方向に隣接する前記永久磁石間に設けられた補助磁極部とを有し、前記永久磁石と前記補助磁極部の間には磁気的な空隙が設けられていることを特徴とする永久磁石回転電機。
【請求項２】固定子と、該固定子の内周側に空隙を介して配置された回転子と、該回転子に形成されると共に周方向に隣接する前記永久磁石間に設けられた補助磁極部とを有し、前記永久磁石と前記補助磁極部の間には磁気的な空隙が設けられていることを特徴とする永久磁石回転電機。
【請求項１】固定子と、該固定子の内周側に空隙を介して配置された回転子と、該回転子に形成されると共に周方向に隣接する前記永久磁石間に設けられた補助磁極部とを有し、前記永久磁石と前記補助磁極部の間には磁気的な空隙が設けられていることを特徴とする永久磁石回転電機。
【請求項２】固定子と、該固定子の内周側に空隙を介して配置された回転子と、該回転子に形成されると共に周方向に隣接する前記永久磁石間に設けられた補助磁極部とを有し、前記永久磁石と前記補助磁極部の間には磁気的な空隙が設けられていることを特徴とする永久磁石回転電機。
【請求項３】請求項１又は２に記載の永久磁石回転電機において、前記空隙には非磁性材が設けられていることを特徴とする永久磁石回転電機。
【請求項４】請求項１又は２に記載の永久磁石回転電機において、前記空隙は、磁束密度分布の変化を緩やかにしてコギングトルクを抑制させるものであることを特徴とする永久磁石回転電機。
【請求項５】駆動装置を備えた電動車両において、前記駆動装置は、請求項１乃至４のいずれかに記載の永久磁石回転電機を有することを特徴とする電動車両。